

# Novel Tools and Test Techniques for the Evaluation of Aeroservoelastic Free-Play, Phase I

Completed Technology Project (2009 - 2009)



## Project Introduction

Control surface free-play is important throughout the lifetime of a flight vehicle. Free-play can result in aeroservoelastic limit cycle oscillations (LCO) with significant amplitude causing degraded mission effectiveness, possibly leading to structural failure. Specifications for allowable free-play size can be overly conservative. Analytical tools are proposed for establishing free-play limits on aeroservoelastic aircraft systems without adverse consequences, justifying relief, which may otherwise be cost prohibitive or impossible to satisfy. The proposed tools include finite element modeling, model order reduction, nonlinear simulation, describing functions, and wavelet transforms. These tools will be integrated into the Matlab<sup>TM</sup>/Simulink<sup>TM</sup> platform. A trade study is proposed that compares different free-play modeling techniques. Novel techniques will be used to determine the airspeed range over which limit cycles can occur, including the frequency and amplitude of the limit cycles. Novel techniques for the inverse problem are also proposed, whereby the free-play size is estimated based on diagnostic measurements. A general stabilator model will be used in Phase I to develop the analysis techniques and show feasibility. Wind tunnel test verification of the free-play analysis and estimation techniques will be conducted in Phase II using existing wind tunnel models and facilities at an industrial location.

## Anticipated Benefits

STI also has long standing relationships with numerous manufacturers of both commercial and military aircraft. This places STI in a unique position to demonstrate this product directly to likely potential industry users. This program will lead to a validated software tool for control surface free-play analysis and identification. The software can be used for aircraft design, flight test operations, post-flight test analysis and actuator maintenance testing. On-line identification of free-play is also a potential application. Target markets are military and commercial aircraft manufacturers. Other markets include industrial machinery and structural analysis.



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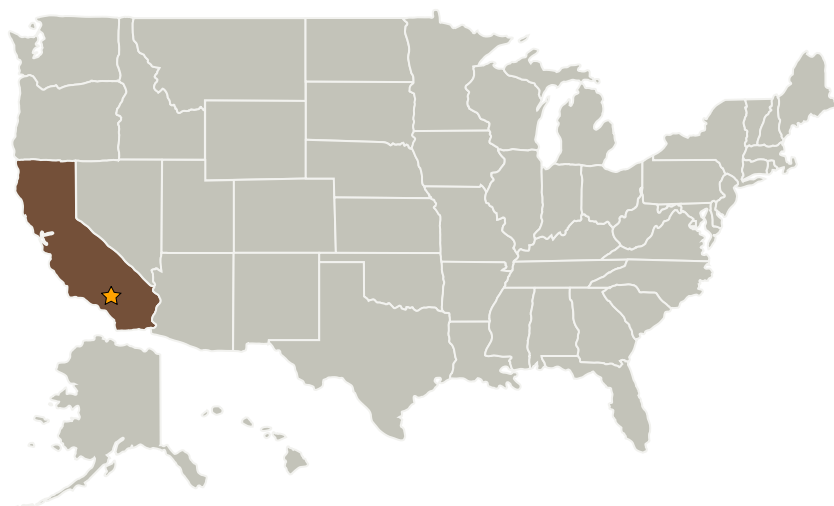
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## Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Armstrong Flight Research Center(AFRC)	Lead Organization	NASA Center	Edwards, California
Systems Technology, Inc	Supporting Organization	Industry	

### Primary U.S. Work Locations

California

## Organizational Responsibility

### Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

### Lead Center / Facility:

Armstrong Flight Research Center (AFRC)

### Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

## Project Management

### Program Director:

Jason L Kessler

### Program Manager:

Carlos Torrez

### Project Manager:

Sunil L Kukreja

### Principal Investigator:

Brian Danowsky

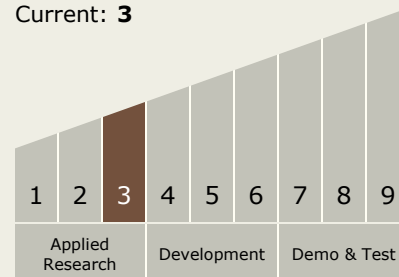
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## Technology Maturity (TRL)

Start: 3  
Current: 3



## Technology Areas

### Primary:

- TX15 Flight Vehicle Systems
  - └ TX15.1 Aerosciences
    - └ TX15.1.3 Aeroelasticity